1 Composition, phytochemicals, and beneficial health effects of dried fruits: an overview

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1.1 Introduction

Dried fruits serve as a concentrated form of fresh fruits prepared by different drying techniques. In other words, dried fruits possess much lower moisture content as a large proportion of their original water has been removed, either naturally through sun drying or through the use of specialized dryers or dehydrators. Considering the 2011 global production of commercially important dried fruits (Table 1.1), dates rank first on a global basis with a production of 6,598,000 metric tonnes (MT), followed by raisins (1,170,999 MT), prunes (236,500 MT), apricots (198,917 MT), and figs (105,453 MT) [1]. To the best of our knowledge, little information is available about the production of other dried fruits (açai berries, apples, bananas, black currants, blackberries, cherries, citrus fruits, cranberries, gingers, goji berries, guavas, kiwis, mangoes, mulberries, nectarines, papayas, passion fruits, peaches, pears, pineapples, raspberries, star apples, and strawberries, among others).

Dates, figs, prunes, raisins, apricots, peaches, apples, and pears are referred to as "conventional" or "traditional" dried fruits. On the other hand, some fruits such as blueberries, cranberries, cherries, strawberries, and mangoes are infused with sugar solutions (e.g., sucrose syrup) or fruit juice concentrates prior to drying. Some products sold as dried fruit, such as papayas and pineapples, are actually candied fruit [2].

Epidemiologic studies have found an association between dried fruit consumption and diet quality. Raisins may be among the most researched of all dried fruits showing a health benefit [3], followed by dates, prunes, figs, apricots, peaches, apples, pears, and other fruits, which together constitute nearly half of all dried fruits produced in the world each year [2].

This overview chapter summarizes the nutritional significance, phytochemical composition, and potential health benefits of dried fruit consumption and discusses their great potential as medicinal or healthy foods for a number of diseases inflicting human beings.

Dried Fruits: Phytochemicals and Health Effects, First Edition. Edited by Cesarettin Alasalvar and Fereidoon Shahidi.

Table 1.1 World dried fruits production (metric tonnes)

Production	2007	2008	2009	2010	2011
Apricots	137,100	146,950	164,350	159,100	198,917
Dates	6,400,000	6,323,000	6,599,000	6,708,000	6,598,000
Figs	100,600	92,000	102,000	107,562	105,453
Prunes	199,204	229,942	253,851	245,630	236,500
Raisins	1,053,500	1,042,450	1,061,600	1,083,547	1,170,999

Source: Adapted from INC [1].

1.2 Compositional and nutritional characteristics of dried fruits

Dried fruits come in almost as many varieties as fresh fruits. Although raisins, figs, dates, prunes, and apricots are the most common dried fruits in the marketplace, health food stores and local markets offer many more choices such as dried apples, pineapples, berries, mangoes, papayas, and even the exotic dragon fruit. They are rich sources of essential nutrients and health-promoting bioactive compounds. Table 1.2 summarizes the nutritional composition of some dried fruits (apples, apricots, dates, figs, peaches, pears, prunes, and raisins) [4]. Dried fruits are rich in carbohydrates (61.33–79.18 g/100 g) and devoid of fat (0.32–0.93 g/100 g). The most calorie-rich of these fruits are raisins (299 kcal/100 g), followed by dates (282 kcal/100 g). Dried fruits are excellent sources of sugar ranging from 38.13 g/100 g in prunes to 63.35 g/100 g in dates. Fructose and glucose are the main sugars found in all dried fruits, followed by sucrose. Trace amounts of maltose and galactose are found in some dried fruits. Levels of sugar may differ according to drying methods and regional and varietal factors.

It is important to note that the high content of dietary fiber (3.7–9.8 g/100 g) found in dried fruits is an important source that helps meet our dietary recommendations (14 g of fiber for every 1000 calories of food consumed each day).This becomes 25–38 g of fiber per day depending on age and gender [5]. On a per serving basis (40 g), dried fruits deliver more than 9% of the daily value of fiber, depending on the fruit [4]. It has been reported that dried fruits (40 g/serving) compare favorably in their fiber content with common fresh fruit (one cup or one fruit serving) options [4, 6].

With respect to nutritional aspects, percentage of recommended dietary allowances (RDA) or adequate intake (AI) of minerals for adult males and females (aged 15–50 years) are also given in Table 1.3. Dried fruits, in general, serve as a reasonable source of copper, iron, magnesium, manganese, phosphorus, and potassium. Among the eight dried fruits listed in Table 1.3, peaches possess the highest mineral content, whereas apples contain the lowest. Consuming 40 g (on a per serving basis) of dried fruits (Table 1.3) supplies 0.6–6.5% of calcium, 8.4–16.4% of copper, 2.1–20.3% of iron, 1.6–8.6% of magnesium, 1.6–11.3% of manganese, 2.2–6.8% of phosphorus, and 3.8–9.9% of potassium for RDA or AI for adults [4, 7–9]. Based on RDA and AI values, dried figs are high in calcium, magnesium, and manganese, whereas dried peaches are good sources of iron and phosphorus. Moreover, apricots are an important source of potassium among the eight dried fruits listed in Table 1.3. On a per serving basis (40 g or about one-fourth cup), dried fruits rank among the top potassium sources in diets around the world [6]. Moreover, on a per serving basis, different dried fruits such as apricots, currants, dates, figs, peaches, prunes, and raisins (40 g serving)

Table 1.2 Compositional and nutritional characteristics of some dried fruits (values in per 100 g edible portion)

Nutrient	Units	Apples	Apricots	Dates[a]	Figs	Peaches	Pears	Prunes	Raisins[b]
Proximate composition									
Water	g	31.76	30.89	20.53	30.05	31.80	26.69	30.92	15.43
Energy	kcal	243	241	282	249	239	262	240	299
Protein	g	0.93	3.39	2.45	3.30	3.61	1.87	2.18	3.07
Lipid	g	0.32	0.51	0.39	0.93	0.76	0.63	0.38	0.46
Ash	g	1.10	2.57	1.60	1.86	2.50	1.11	2.64	1.85
Carbohydrate	g	65.89	62.64	75.03	63.87	61.33	69.70	63.88	79.18
Dietary fiber	g	8.7	7.3	8.0	9.8	8.2	7.5	7.1	3.7
Sugars	g	57.19	53.54	63.35	47.92	41.74	62.20	38.13	59.19
Minerals									
Calcium	mg	14	55	39	162	28	34	43	50
Copper	mg	0.19	0.34	0.21	0.29	0.36	0.37	0.28	0.32
Fluoride	µg	nd	nd	nd	nd	nd	nd	4.0	234
Iron	mg	1.40	2.66	1.02	2.03	4.06	2.10	0.93	1.88
Magnesium	mg	16	32	43	68	42	33	41	32
Manganese	mg	0.09	0.24	0.26	0.51	0.31	0.33	0.30	0.30
Phosphorus	mg	38	71	62	67	119	59	69	101
Potassium	mg	450	1162	656	680	996	533	732	749
Selenium	µg	1.3	2.2	3.0	0.6	0.5	0.2	0.3	0.6
Sodium	mg	87	10	2	10	7	6	2	11
Zinc	mg	0.20	0.39	0.29	0.55	0.57	0.39	0.44	0.22
Vitamins									
Betaine	mg	nd	0.30	0.4	0.7	nd	nd	0.4	0.3
Choline	mg	17.6	13.9	6.3	15.8	12.7	23.0	10.1	11.1
Folate	µg	nd	10.0	19.0	9.0	nd	nd	4.0	5.0
Niacin	mg	0.93	2.59	1.27	0.62	4.38	1.37	1.88	0.77
Pantothenic acid	mg	0.25	0.52	0.59	0.43	0.56	0.15	0.42	0.10
Pyridoxine	mg	0.13	0.14	0.17	0.11	0.07	0.07	0.21	0.17
Riboflavin	mg	0.16	0.07	0.07	0.08	0.21	0.15	0.19	0.13

(*continued*)

Table 1.2 (*Continued*)

Nutrient	Units	Apples	Apricots	Dates[a]	Figs	Peaches	Pears	Prunes	Raisins[b]
***Vitamins* (*cont.*)**									
Thiamin	mg	nd	0.02	0.05	0.09	tr	0.01	0.05	0.11
Vitamin A (RAE)	μg	nd	180	tr	tr	108	nd	39	nd
Vitamin C	mg	3.9	1.0	0.4	1.2	4.8	7.0	0.6	2.3
Vitamin E (ATE)	mg	0.53	4.33	0.05	0.35	0.19	0.06	0.43	0.12
Vitamin K	μg	3.00	3.10	2.70	15.6	15.7	20.4	59.5	3.5
Amino acids									
Alanine	g	0.033	0.110	0.083	0.134	0.215	0.062	0.066	0.105
Arginine	g	0.029	0.066	0.136	0.077	0.092	0.032	0.037	0.413
Aspartic acid	g	0.162	0.937	0.213	0.645	0.602	0.368	0.801	0.110
Cystine	g	0.012	0.019	0.067	0.036	0.029	0.018	0.011	0.019
Glutamic acid	g	0.097	0.188	0.359	0.295	0.548	0.135	0.114	0.164
Glycine	g	0.037	0.070	0.101	0.108	0.126	0.054	0.047	0.080
Histidine[c]	g	0.015	0.047	0.032	0.037	0.067	0.020	0.027	0.072
Isoleucine[c]	g	0.037	0.063	0.049	0.089	0.104	0.054	0.041	0.057
Leucine[c]	g	0.057	0.105	0.084	0.128	0.204	0.094	0.066	0.096
Lysine[c]	g	0.058	0.083	0.066	0.088	0.116	0.066	0.050	0.084
Methionine[c]	g	0.009	0.015	0.022	0.034	0.087	0.022	0.016	0.021
Phenylalanine[c]	g	0.026	0.062	0.050	0.076	0.114	0.049	0.052	0.065
Proline	g	0.032	0.821	0.130	0.610	0.152	0.051	0.130	0.254
Serine	g	0.038	0.087	0.057	0.128	0.167	0.067	0.059	0.070
Threonine[c]	g	0.033	0.073	0.043	0.085	0.141	0.049	0.049	0.077
Tryptophan[c]	g	0.009	0.016	0.012	0.020	0.010	nd	0.025	0.050
Tyrosine	g	0.017	0.039	0.015	0.041	0.094	0.016	0.021	0.012
Valine[c]	g	0.043	0.078	0.071	0.122	0.197	0.066	0.056	0.083

Source: Adapted from USDA [4].
Note: Some numbers are rounded to the second digit after decimal point.
RAE, retinol activity equivalents; ATE, α-tocopherol equivalents; nd, not detected; tr, trace.
[a]Deglet noor.
[b]Seedless.
[c]Indispensable amino acids.

Table 1.3 Percentage of RDA values for adults (aged 19–50) in 40 g of dried fruits (per serving basis)

Mineral	RDA or AI*	Unit	Apples	Apricots	Dates[a]	Figs	Peaches	Pears	Prunes	Raisins[b]	Reference
Males											
Calcium	1000 mg/day*	mg	0.6	2.2	1.6	6.5	1.1	1.4	1.7	2.0	[4, 7]
Copper	0.9 mg/day	mg	8.4	15.1	9.3	12.9	16.0	16.4	12.4	14.2	[4, 8]
Fluoride	4000 μg/day*	μg	nd	nd	nd	nd	nd	nd	tr	2.3	[4, 7]
Iron	8 mg/day	mg	7.0	13.3	5.1	10.2	20.3	10.5	4.7	9.4	[4, 8]
Magnesium	400–420 mg/day	mg	1.6	3.1	4.2	6.6	4.1	3.2	4.0	3.1	[4, 7]
Manganese	2.3 mg/day*	mg	1.6	4.2	4.5	8.9	5.4	5.7	5.2	5.2	[4, 8]
Phosphorus	700 mg/day	mg	2.2	4.1	3.5	3.8	6.8	3.4	3.9	5.8	[4, 7]
Potassium	4700 mg/day	mg	3.8	9.9	5.6	5.8	8.5	4.5	6.2	6.4	[4, 9]
Selenium	55 μg/day	μg	0.9	1.6	2.2	0.4	0.4	0.1	0.2	0.4	[4, 10]
Sodium	1500 mg/day	mg	2.3	0.3	0.1	0.3	0.2	0.2	0.1	0.3	[4, 9]
Zinc	11 mg/day	mg	0.7	1.4	1.1	2.0	2.1	1.4	1.6	0.8	[4, 8]
Females											
Calcium	1000 mg/day*	mg	0.6	2.2	1.6	6.5	1.1	1.4	1.7	2.0	[4, 7]
Copper	0.9 mg/day	mg	8.4	15.1	9.3	12.9	16.0	16.4	12.4	14.2	[4, 8]
Fluoride	3000 μg/day*	μg	nd	nd	nd	nd	nd	nd	tr	3.1	[4, 7]
Iron	18 mg/day	mg	3.1	5.9	2.3	4.5	9.0	4.7	2.1	4.2	[4, 8]
Magnesium	310–320 mg/day	mg	2.0	4.1	5.5	8.6	5.3	4.2	5.2	4.1	[4, 7]
Manganese	1.8 mg/day*	mg	2.0	5.3	5.8	11.3	6.9	7.3	6.7	6.7	[4, 8]
Phosphorus	700 mg/day	mg	2.2	4.1	3.5	3.8	6.8	3.4	3.9	5.8	[4, 7]
Potassium	4700 mg/day	mg	3.8	9.9	5.6	5.8	8.5	4.5	6.2	6.4	[4, 9]
Selenium	55 μg/day	μg	0.9	1.6	2.2	0.4	0.4	0.1	0.2	0.4	[4, 10]
Sodium	1500 mg/day	mg	2.3	0.3	0.1	0.3	0.2	0.2	0.1	0.3	[4, 9]
Zinc	8 mg/day	mg	1.0	2.0	1.5	2.8	2.9	2.0	2.2	1.1	[4, 8]

RDA, recommended dietary allowances; AI*, adequate intake; nd, not detected; tr, trace.
[a]Deglet noor.
[b]Seedless.

compare positively in their potassium content with the 10 most common fresh fruit options such as apples, bananas, grapes, mangos, oranges, peaches, pears, pineapples, strawberries, and watermelons (one cup or one fruit serving) [4, 6].

Dried fruits contain both water-soluble (betaine, choline, folate, niacin, pantothenic acid, pyridoxine, riboflavin, thiamine, and vitamin C) and fat-soluble vitamins (A, E, and K) (Table 1.2). Among the eight dried fruits listed, prunes are the richest source of vitamin K (59.5 μg/100 g), whereas apricots are the richest source of vitamin A (180 μg/100 g) and vitamin E (4.33 mg/100 g) [4]. Dried fruits, in general, contain a small amount of vitamin C. With regard to RDA of vitamins, 40 g dried fruits provide up to 1.6–12.5% of niacin, 0.8–4.7% of pantothenic acid, 2.2–6.5% of pyridoxine, 2.2–7.6% of riboflavin, and 0.9–26.4% of vitamin K for RDA or AI for adults [4, 8, 10, 11]. Prunes are particularly high in vitamin K. Among these eight dried fruits, prunes, apricot, and peaches contain higher amounts of vitamins than other dried fruits (Tables 1.2 and 1.4).

Despite the fact that dried fruits contain all indispensable amino acids (except tryptophan in pears), in general, they are not good sources of amino acids due to their low protein content (Table 1.2).

In summary, the following are some nutritional facts about dried fruits [12]:

- Dried fruits are low in their fat and sodium content and, as expected, devoid of trans-fats and cholesterol [4].
- Dried fruits are good sources of dietary fiber and potassium. Among all fruits, they are among the top five contributors of fiber and potassium [5].
- Dried fruits provide essential nutrients that are otherwise low in today's diet, such as vitamin A (apricots and peaches), calcium (figs), vitamin K (prunes), boron (raisins and prunes), iron, and copper [4, 13].
- Traditional dried fruits have no added sugars. Most traditional dried fruits contain low amounts of sucrose; their sugar content is in the form of fructose and glucose [4].

1.3 Phytochemicals in dried fruits

Phytochemicals are defined as nonnutritive, naturally occurring, biologically active, and chemically derived compounds found in the plant kingdom. More than several thousands of individual phytochemicals have been identified in plant-derived foods and their by-products, but a large percentage of phytochemicals still remain unknown and need to be identified before we can fully understand the health benefits of phytochemicals in whole foods. Dried fruits are highly nutritious and provide a range of phytochemicals such as phenolic acids, flavonoids (anthocyanidins, flavan-3-ols, flavones, flavonols, and isoflavones), phytoestrogens, and carotenoids, among others [3, 4, 14–28]. They, in general, contain traces or undetectable amounts of proanthocyanidins [29]. Proanthocyanidins detected in plums and grapes are absent in prunes and raisins, which suggests that these compounds are degraded during the drying process [30].

Dried fruits are excellent sources of phenolic compounds in the diet [31–35]. These make up the largest group of plant phytochemicals in the diet and they appear to be, at least in part, responsible for the health benefits associated with diets abundant in fruits and vegetables. Phenolic compounds contribute most to the antioxidant activity of fruits and vegetables [36] and have a multitude of functional capacities, which may have a beneficial effect on health [6].

Table 1.4 Percentage of RDA values for adults (aged 19–50 years) in 40 g of dried fruits (per serving basis)

Vitamin	RDA or AI*	Unit	Apples	Apricots	Dates[a]	Figs	Peaches	Pears	Prunes	Raisins[b]	Reference
Males											
Choline	550 mg/day*	mg	1.3	1.0	0.5	1.1	0.9	1.7	0.7	0.8	[4, 11]
Folate	400 μg/day	μg	nd	1.0	1.9	0.9	nd	nd	0.4	0.5	[4, 11]
Niacin	16 mg/day	mg	2.3	6.5	3.2	1.6	11.0	3.4	4.7	1.9	[4, 11]
Pantothenic acid	5 mg/day*	mg	2.0	4.2	4.7	3.4	4.5	1.2	3.4	0.8	[4, 11]
Pyridoxine	1.3 mg/day	mg	4.0	4.3	5.2	3.4	2.2	2.2	6.5	5.2	[4, 11]
Riboflavin	1.3 mg/day	mg	4.9	2.2	2.2	2.5	6.5	4.6	5.8	4.0	[4, 11]
Thiamin	1.2 mg/day	mg	nd	0.7	1.7	3.0	tr	0.3	1.7	3.7	[4, 11]
Vitamin A (RAE)	900 μg/day	μg	nd	8.0	tr	tr	4.8	nd	1.7	nd	[4, 8]
Vitamin C	90 mg/day	mg	1.7	0.4	0.2	0.5	2.1	3.1	0.3	1.0	[4, 10]
Vitamin E (ATE)	15 mg/day	mg	1.4	11.5	0.1	0.9	0.5	0.2	1.1	0.3	[4, 10]
Vitamin K	120 μg/day*	μg	1.0	1.0	0.9	5.2	5.2	6.8	19.8	1.2	[4, 8]
Females											
Choline	425 mg/day*	mg	1.7	1.3	0.6	1.5	1.2	2.2	1.0	1.0	[4, 11]
Folate	400 μg/day	μg	nd	1.0	1.9	0.9	nd	nd	0.4	0.5	[4, 11]
Niacin	14 mg/day	mg	2.7	7.4	3.6	1.8	12.5	3.9	5.4	2.2	[4, 11]
Pantothenic acid	5 mg/day*	mg	2.0	4.2	4.7	3.4	4.5	1.2	3.4	0.8	[4, 11]
Pyridoxine	1.3 mg/day	mg	4.0	4.3	5.2	3.4	2.2	2.2	6.5	5.2	[4, 11]
Riboflavin	1.1 mg/day	mg	5.8	2.5	2.5	2.9	7.6	5.5	6.9	4.7	[4, 11]
Thiamin	1.1 mg/day	mg	nd	0.7	1.8	3.3	tr	0.4	1.8	4.0	[4, 11]
Vitamin A (RAE)	700 μg/day	μg	nd	10.3	tr	tr	6.2	nd	2.2	nd	[4, 8]
Vitamin C	75 mg/day	mg	2.1	0.5	0.2	0.6	2.6	3.7	0.3	1.2	[4, 10]
Vitamin E (ATE)	15 mg/day	mg	1.4	11.5	0.1	0.9	0.5	0.2	1.1	0.3	[4, 10]
Vitamin K	90 μg/day*	μg	1.3	1.4	1.2	6.9	7.0	9.1	26.4	1.6	[4, 8]

RDA, recommended dietary allowances; AI*, adequate intake; RAE, retinol activity equivalents; ATE, α-tocopherol equivalents; nd, not detected; tr, trace.
[a]Deglet noor.
[b]Seedless.

Table 1.5 Comparison of total phenolics and ORAC values of some dried fruits (values in per 100 g edible portion)

Dried fruits	Total phenolics (mg of GAE/100 g)	Total ORAC (μmol of TE/100 g)	Reference
Apples[a]	324	6,681	[14, 17]
Apricots[a]	248	3,234	[14, 17]
Dates (Deglet noor)	661	3,895	[14, 21]
Dates (Medjool)	572	2,387	[14, 21]
Figs	960	3,383	[14, 21]
Peaches[a]	283	4,222	[14, 17]
Pears[a]	679	9,496	[14, 17]
Prunes	1195	8,578	[14, 21]
Raisins (golden seedless)	–	10,450	[14, 19]
Raisin (seedless)	1065	3,037	[14, 21]
Raisins (white)[a]	372	4,188	[14, 17]

GAE, gallic acid equivalents; TE, trolox equivalents.
[a]Dried to 40% moisture (purchased in Italy).

Values of the total phenolic content and oxygen radical absorbance capacity (ORAC) for a selection of dried fruit are given in Table 1.5. Prunes have the highest total phenolic content (1195 mg of gallic acid equivalents (GAE)/100 g), whereas raisins (golden seedless) have the highest ORAC value (10,450 μmol trolox equivalents (TE)/100 g). Significant differences in the total phenolic content and the ORAC value exist among raisin varieties, being lowest in white raisins and highest in golden seedless raisins [14, 17, 19, 21]. Values are much higher for dried fruits than the corresponding values for their fresh counterparts because antioxidants become concentrated after the drying or dehydration process. While there is a loss or modification of some specific phytochemicals during drying, antioxidant activity and the total phenolic content remain relatively unchanged during the process, implying that many of the phenolic compounds are yet unidentified [37]. This could include oligomeric or polymeric products that are difficult to characterize. Pellergrini *et al*. [38] measured the total antioxidant capacity (using three different *in vitro* assays) of food including four dried fruits (apricots, figs, prunes, and raisins). Among these fruits, prunes exhibited the highest value followed by apricots. Little information is available on the phenolic profiles and antioxidant components of the other dried fruits.

The 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging activity and polyphenol content of 22 dried fruits (apples, apricots, bananas, blueberries, cherries, cranberries, figs, raisins, hawthorns, jujube, kiwis, kumquats, mangoes, melons, muscats, papayas, peaches, pears, pineapples, prunes, rakankas, and strawberries) have been evaluated and compared with fresh fruits by Ishiwata *et al*. [39]. Among the dried fruits examined, hawthorns, apricots, and blueberries exhibited the highest DPPH radical-scavenging activity. The polyphenol content of dried fruits and DPPH radical-scavenging activity were highly correlated. On a fresh weight basis, dried fruits, in general, contain higher radical-scavenging activity than fresh fruits. In contrast, the radical-scavenging activity of dried fruits is lower than that of the corresponding fresh fruits on a fresh weight basis [39]. A similar pattern was also reported by Vinson *et al*. [40].

Vinson *et al*. [40] reported the total phenolic content of fresh and dried fruits (apricots, cranberries, dates, figs, grapes/raisins, and plums/prunes) (Figure 1.1a). Dates had the highest

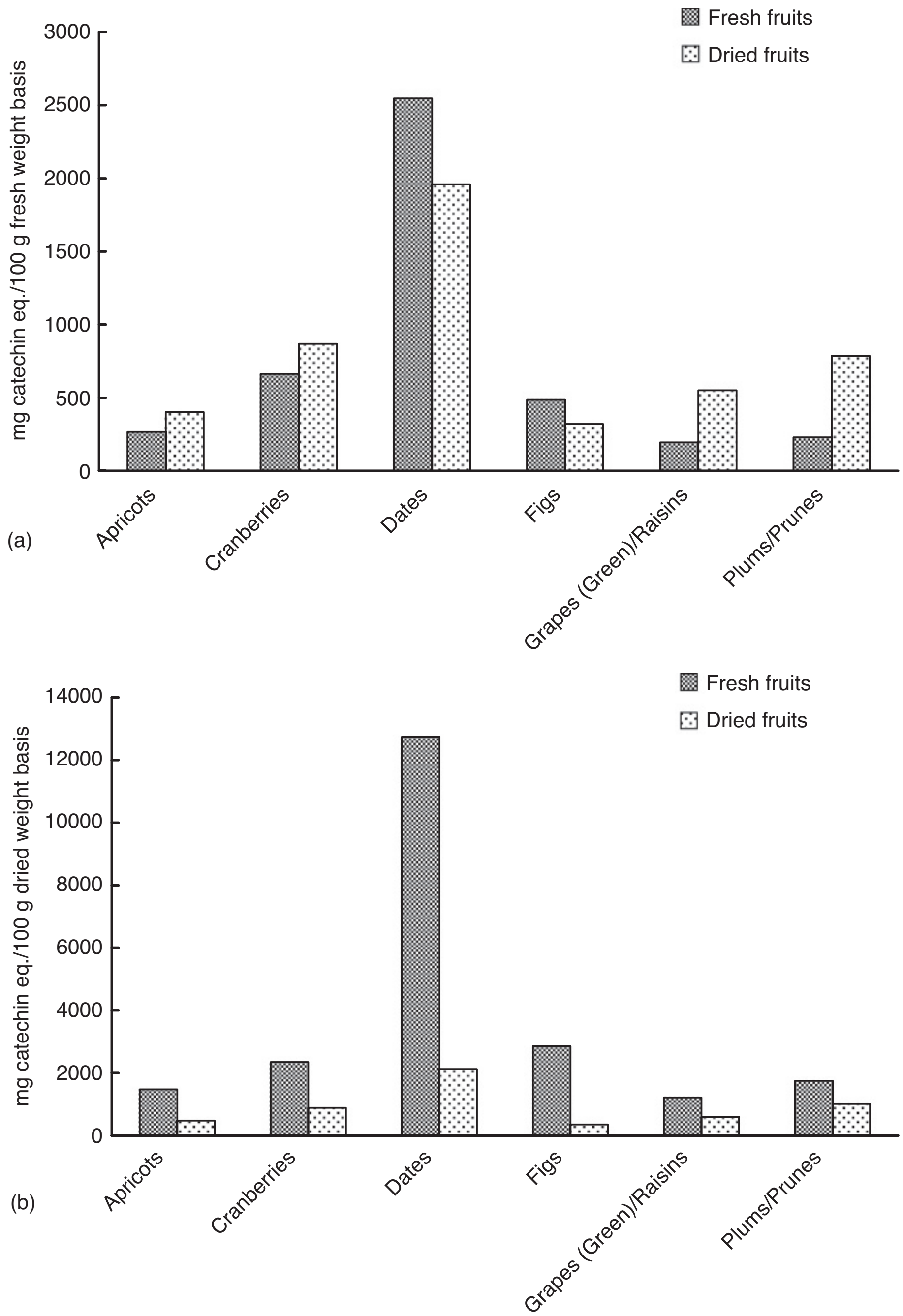

Figure 1.1 Comparison of quantity of total phenol in fresh and the corresponding dried fruit on a fresh weight basis (a) and dry weight basis (b). (Adapted with permission from Vinson *et al.* [40]).

concentration of total phenolics in both fresh and dried versions (2546 and 1959 mg catechin equivalents (CE)/100 g on a fresh weight basis, respectively). The total phenolic content averaged 731 mg of CE/100 g for fresh fruits and 815 mg of CE/100 g for dried fruits [40]. A comparison of the quantity of total phenolics in fresh and dried fruit pairs on a dry weight basis is illustrated in Figure 1.1b. The average is 3730 mg of CE/100 g for fresh fruits and only 910 mg of CE/100 g for dried varieties [40]. The process of producing dried fruit significantly decreases the total phenol content of the fruits on a dry weight basis. Dried fruits are significantly higher ($P < 0.005$) in total phenols than 20 fresh fruits, 815 versus 173 mg/100 g, respectively [41].

Flavonoids are another group of phenolic compounds that can be classified into seven groups: flavanones, flavones, isoflavones, anthocyanidins, flavonols, flavononols, and flavanols or flavan-3-ols [42]. Flavonoids, which are the most common and widely distributed group of plant phenolics, are increasingly appreciated as an important component of the human diet. Humans consume approximately 1 g of flavonoids per day [43]. Different classes (anthocyanidins, flavan-3-ols, flavones, and flavonols) and amounts of flavonoids have been reported for different dried fruits [15, 18, 23, 24]. Despite the fact that raisins contain the above-mentioned classes of flavonoids, the total content of flavonoids among the four dried fruits listed in Table 1.6 varies between 0.85 mg/100 g in raisins and 7.66 mg/100 g in cranberries. Dried fruits contain traces or undetectable amounts of anthocyanins, which are likely degraded to phenolic acids. Dates contain one anthocyanidin (such as cyanidin) and one flavonol (such as quercetin). Flavan-3-ols are only present in raisins.

The available data show that dried fruits have a unique spectrum of phenols, polyphenols, and tannins. For example, in raisins, the most abundant phenolic compounds are the

Table 1.6 Comparison of flavonoids (mg/100 g edible portion) of some dried fruits

Flavonoid	Cranberries [15, 23]	Dates[a] [15, 24]	Prunes [15, 23, 24]	Raisins[b] [15, 18, 23, 24]
Anthocyanidins				
Cyanidin	0.60	1.70	0.71	0.03
Delphinidin	0.10	–	0.04	0.01
Pelargonidin	0.02	–	–	0.01
Flavan-3-ols				
(−)-Epicatechin	–	–	–	0.10
(+)-Catechin	–	–	–	0.42
Flavones				
Apigenin	0.01	–	–	–
Luteolin	0.02	–	0.01	0.01
Flavonols				
Kaempferol	0.01	–	0.01	0.01
Myricetin	2.40	–	0.01	0.01
Quercetin	4.50	0.93	1.80	0.25
Total	7.66	2.63	2.58	0.85

[a]Deglet noor.
[b]Seedless.

flavonoids quercetin (Table 1.6) and phenolic acids caftaric and coutaric acids [3]. The predominant phenolic compounds in Greek currants (raisins) are vanillic, caffeic, gallic, syringic, *p*-coumaric, and protocatechuic acids and the flavonoid quercetin [44]. Hydroxycinnamic acids, especially chlorogenic acid isomers, are the major phenolics in prunes, representing more than 94% of the total [45]. Rutin is the predominant flavonol in prunes and prune juice [26]. Prunes also contain quinic acid that is metabolized to hippuric acid, which, as some research suggests, helps prevent urinary tract infections [35, 46]. Four free phenolic acids (protocatechuic, vanillic, syringic, and ferulic) and nine bound phenolic acids (gallic, protocatechuic, *p*-hydroxybenzoic, vanillic, caffeic, syringic, *p*-coumaric, ferulic, and *o*-coumaric) have been reported in fresh and sun-dried Omani dates of three native varieties [47]. Nutritional and functional properties as well as phytochemical characteristics (carotenoids, phytosterols, polyphenols, phenolic acids, flavonoids, anthocyanins, and phytoestrogens) of dates have been extensively reviewed [28, 48].

Phytoestrogens comprise three major classes: isoflavones, lignans, and coumestan. Some dried fruits (such as apricots, currants, dates, prunes, and raisins) have been reported to contain phytoestrogens [such as isoflavones (formononetin, daidzein, genistein, and glycitein), lignans (matairesinol, lariciresinol, pinoresinol, and secoisolariciresinol), and coumestan (coumestrol)]. Apricots contain the highest concentration of total phytoestrogens (444.5 μg/100 g) among the five dried fruits listed in Table 1.7, followed by dates (329.5 μg/100 g), prunes (183.5 μg/100 g), currants (34.1 μg/100 g), and raisins (30.2 μg/100 g) [25]. Coumestan, measured as coumestrol, is generally present in low concentrations within dried fruit groups. Dried fruits have higher concentration of lignans (ranging from 20.9 to 400.5 μg/100 g) than isoflavones (ranging from 4.2 to 39.8 μg/100 g) [25].

Five carotenoids (namely, α-carotene, β-carotene, β-cryptoxanthin, lutein, and zeaxanthin) are present in some dried fruits. Of these, β-carotene, which acts as provitamin A, is the

Table 1.7 Comparison of phytoestrogen content of some dried fruits (μg/100 g edible portion)

Phytoestrogen	Apricots[a]	Currants	Dates[b]	Prunes[c]	Raisins[d]
Formononetin	12.5	0.6	0.4	0.5	0.4
Daidzein	6.4	2.2	1.2	2.6	1.5
Genistein	19.8	10.0	3.4	0.2	5.2
Glycitein	1.1	0.2	0.2	0.9	1.0
Total isoflavones	39.8	13.1	5.1	4.2	8.1
Matairesinol	0.6	1.1	0.3	0.2	0.4
Lariciresinol	62.1	5.8	116.9	2.1	9.2
Pinoresinol	190.1	3.0	100.2	71.5	0.8
Secoisolariciresinol	147.6	10.9	106.2	103.8	11.5
Total lignans	400.5	20.9	323.6	177.5	22.0
Coumestrol	4.2	0.1	0.8	1.8	0.2
Total coumestan	4.2	0.1	0.8	1.8	0.2
Total phytoestrogens	444.5	34.1	329.5	183.5	30.2

Source: Adapted with permission from Thompson *et al.* [25].
[a]Turkish.
[b]Whole pitted.
[c]Whole pitted.
[d]California seedless.

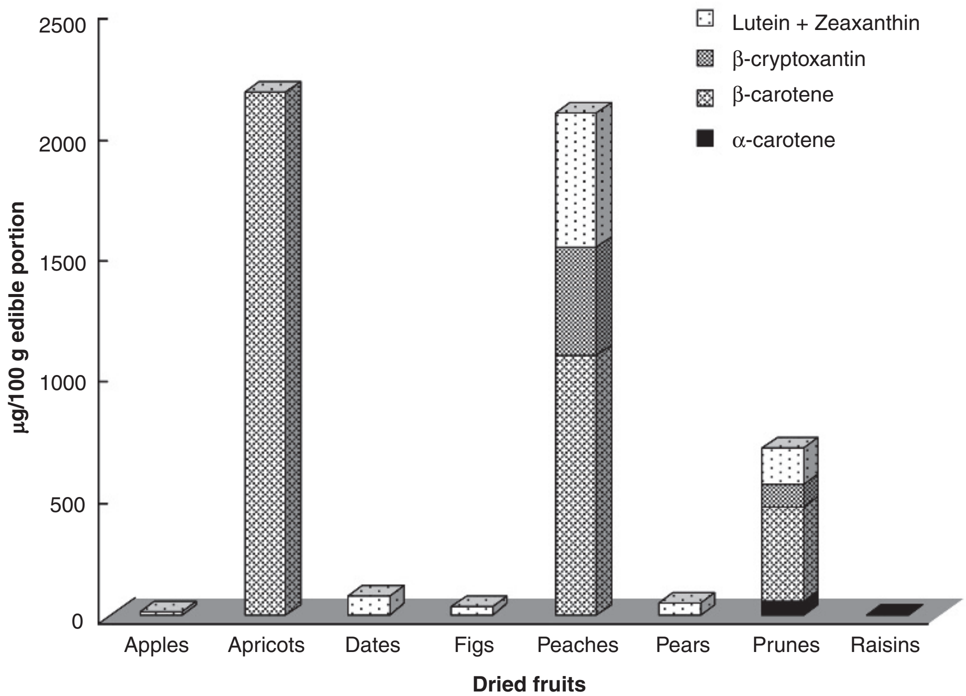

Figure 1.2 Carotenoid content of selected dried fruits on a fresh weight basis. (Adapted from USDA [4]).

most abundant in dried apricots (2163 μg/100 g), peaches (1074 μg/100 g), and prunes (394 μg/100 g), followed by lutein + zeaxanthin in peaches (559 μg/100 g), and β-cryptoxanthin in peaches (444 μg/100 g) [4]. No carotenoids are present in raisins and small and/or trace amounts of carotenoids are found in apples, dates, figs, and pears (Figure 1.2).

In summary, the following are some of the health protective components in dried fruits [12]:

- Dried fruits are good sources of phytochemicals [3, 4, 14–28].
- By virtue of their high phytochemical content, dried fruits are an important source of antioxidants in the diet [21, 28, 40]. Dried apricots and peaches are good sources of carotenoids [4].
- Dried fruits, such as prunes, provide pectin, a soluble fiber that may lower blood cholesterol [49].
- Dried fruits, such as raisins, are a source of prebiotic compounds in the diet. They contain fructooligosaccharides such as inulin that contributes to colon health [50, 51].
- Dried fruits contain organic acids such as tartaric acid (raisins) and sugar alcohol such as sorbitol (prunes). These compounds and fiber appear to work synergistically to maintain a healthy digestive system. They may also help increase the bioavailability of minerals in the diet, such as calcium and iron [52].

1.4 Beneficial health effects of dried fruits

As shown by multiple epidemiological studies, fruit and vegetable consumption reduces the risk of many chronic diseases such as cancer [53–55], heart disease [56, 57], stroke [58], obesity [59], and type 2 diabetes [59, 60], among others [28]. Additionally, there is an inverse relationship between fruit and vegetable intake and blood pressure [61]. The US National Cancer Institute (NCI) and National Research Council (NRC) recommend at least five servings of fruits and vegetables daily. Similarly, the World Health Organization (WHO) recommends 400 g of fruits and vegetables per day or the equivalent of five servings of 80 g each [62].

Numerous health benefits of dried fruits have been reported [6, 28, 40, 51, 55, 63, 64] and reviewed individually throughout this book. The health benefits of dried fruits mainly originate from their essential nutrients and phytochemicals (such as anthocyanidins, carotenoids, phytoestrogen, flavan-3-ols, flavones, flavonols, and phenolic acids, among others) as well as their antioxidant activities. The intake of flavonoids (major part of phytochemicals) has been associated with a lower incidence of various diseases such as cancer, stroke, cardiovascular disease (CVD), and other chronic disorders [65–67]. The positive health effects of flavonoids are probably related to their strong antioxidant properties, among other mechanisms and effects [68, 69]. There is considerable research supporting the role of dried fruits, particularly, in promoting digestive health [51, 70, 71]. Dried fruits, particularly prunes, play a role in supporting bone health [63, 64, 72]. Finally, dried fruits, such as raisins, may promote healthy teeth and gums [73–75].

Dried fruits are important sources of potassium and dietary fiber. Increasing dietary potassium intake can lower blood pressure [76]. Higher fiber diets are recommended to reduce the risk of developing various conditions including constipation, type 2 diabetes, obesity, diverticulitis, colorectal cancer, and CVD [6]. Dried fruits may contribute to healthy body weights. According to the National Health and Nutrition Examination Survey (1999–2004), data showed that intake of dried fruit was associated with a lower body mass index (BMI), reduced waist circumference, abdominal obesity, and improved diet quality [77]. Emerging data suggest that dried fruit promotes satiety by affecting the levels of hormones such as leptin and regulates appetite [78].

Because of the sweetness of dried fruits, it is expected to exert a high glycemic index (70 and above) and insulin response. Recent studies have shown that dried fruits have a low (55 and under) to moderate (56–69) glycemic and insulin index (Table 1.8) and glycemic and

Table 1.8 Glycemic index (GI) of some dried fruits

Dried fruits	GI[a]	Reference
Apples	29	[79]
Apricots	30	[79]
Dates	39	[80]
Figs	61	[79]
Peaches	35	[79]
Prunes	29	[79]
Raisins	52	[81]

[a]High GI (70 and above), moderate GI (56–69), and low GI (55 and under).

insulin response comparable to those in fresh fruits [80–83]. This could be due to the presence of fiber, polyphenols, and tannins that can modify the response [84–87]. Foods with a low glycemic index may help decrease the risk of diabetes and are useful in the management of the established condition [6].

As part of a diet study involving 13,292 participants, dried fruit consumers were defined as those who consume at least one-eighth cup-equivalent of fruit per day [88]. Dried fruit consumption is associated with a lower body weight, improved adiposity measures, higher overall diet quality, and higher nutrient intake of vitamins A, E, and K, phosphorus, magnesium, and potassium. These benefits are attributed to a higher fiber content, reduced intake of solid fats, alcohol, and added sugars. However, only 7% of the subjects in the study consumed significant amounts of dried fruits in their diet, which questions the effectiveness of ongoing public health campaigns around the world that encourage an increase in fruit consumption.

Given many of the benefits of dried fruits in terms of health maintenance, what might dried fruits contribute to an increase in fresh and dried fruit consumption while also offering meaningful health benefits beyond their nutritive value? The answer may lie in focusing on foods that offer significant antioxidant and anti-inflammatory benefits.

1.5 Commercial products and industrial applications of dried fruits

Dried fruits are widely used as ingredients in packaged snacks, confectionary products, baked goods, cereals, energy and nutritional bars, ready-to-eat salads, and sweet industries, among many other specialty foods [89].

Fruits can be dried whole (e.g., grapes, apricots, and plums), in halves, as slices, or diced (e.g., mangoes, papayas, and kiwis). Alternatively, they can be chopped after drying (e.g., dates), made into pastes or concentrated juices. Fruits can also be dried in puree form, as leathers, or as a powder, by spray drying. Some fruits can be freeze-dried (e.g., strawberries, raspberries, cherries, apples, and mangoes, among others). The freeze-dried fruits become very light and crispy and retain much of their original flavor (taste and aroma) and phytochemicals [12].

1.6 Conclusions

Dried fruits, with their unique combination of taste and aroma, essential nutrients, fiber, and phytochemicals or bioactive compounds, are a convenient step toward healthier eating and a means to bridge the gap between recommended intake of fruits and actual consumption. They should be included together with fresh fruit recommendations around the world since they help meet dietary guidelines for daily fruit serving (recommended five servings per day) and address barriers to fruit intake. Dried fruits in smaller serving sizes, ranging from 30 to 43 g depending on the fruit, are considered nutritionally equivalent to fresh fruits in current dietary recommendations in different countries [6, 90, 91]. Numerous scientific evidences suggest that individuals who regularly consume generous amounts of dried fruits have a lower rate of CVD, obesity, various types of cancer, type 2 diabetes, and other chronic diseases. Therefore, dried fruits should be consumed daily in order to get full benefit of nutrients, health-promoting phytochemicals, and antioxidants they contain, together with their unique and desirable taste and aroma.

References

1. INC (2012) *World Dried Fruits Production*. International Nut and Dried Fruit Council Foundation, Reus, Spain.
2. Barta, J. (2006) Fruit drying principles. In: *Handbook of Fruits and Fruit Processing* (ed. Y.H. Hui). Blackwell Publishing, Oxford, UK, pp. 81–94.
3. Willimason, G. & Carughi, A. (2010) Polyphenol content and health benefits of raisins. *Nutrition Research*, **30**, 511–519.
4. USDA (2010) *National Nutrient Database for Standard Reference, Release 23*. Published online at: http://www.nal.usda.gov/fnic/foodcomp/search/, last accessed March 7, 2011.
5. USDA (2005) *Carbohydrates. Dietary Guidelines for Americans*. US Department of Agriculture and US Department of Health and Human Services. Government Printing Office, Washington, DC.
6. INC (2011) Traditional dried fruits: valuable tools to meet dietary recommendations for fruit intake. Paper given at the *XXX World Nut and Dried Fruit Congress*, Budapest, Hungary, May 20–22, 2011 (Dried Fruit Round Table).
7. DRIs (1997) *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* The National Academies Press, Washington, DC.
8. DRIs (2001) *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. The National Academies Press, Washington, DC.
9. DRIs (2004) *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*. The National Academies Press, Washington, DC.
10. DRIs (2000) *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*. The National Academies Press, Washington, DC.
11. DRIs (1998) *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline*. The National Academies Press, Washington, DC.
12. Dried Fruit (2011) Published online at: http://en.wikipedia.org/wiki/Dried_fruit, last accessed July 18, 2011.
13. Rainey, C.J., Nyquist, L.A., Christensen, R.E., Strong, P.L., Culver, B.D. & Coughlin, R. (1999) Daily boron intake from the American diet. *Journal of the American Dietetic Associations*, **99**, 335–340.
14. USDA (2010) *USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2.0.* Published online at: http://www.ars.usda.gov/nutrientdata, last accessed March 9, 2011.
15. USDA (2011) *USDA Database for the Flavonoid Content of Selected Foods, Release 3.* Published online at: http://www.ars.usda.gov/nutrientdata, last accessed November 2, 2011.
16. USDA (2008) *USDA Database for the Isoflavone Content of Selected Foods, Release 2.0.* Published online at: http://www.ars.usda.gov/nutrientdata, last accessed March 9, 2011.
17. Bacchiocca, M., Biagiotti, E. & Ninfali, P. (2006) Nutritional and technological reasons for evaluating the antioxidant capacity of vegetable products. *Italian Journal of Food Science*, **18**, 209–217.
18. Arts, I.C.W., van de Putte, B. & Hollman, P.C.H. (2000) Catechin contents of foods commonly consumed in the Netherlands. 1. Fruits, vegetables, staple foods, and processed foods. *Journal of Agricultural and Food Chemistry*, **48**, 1746–1751.
19. Parker, T.L., Wang, X.-H., Pazmiño, J. & Engeseth, N.J. (2007) Antioxidant capacity and phenolic content of grapes, sun-dried raisins, and golden raisins and their effect on *ex vivo* serum antioxidant capacity. *Journal of Agricultural and Food Chemistry*, **55**, 8472–8477.
20. Horn-Ross, P.L., Barnes, S., Lee, M., Coward, L., Mandel, J.E., Koo, J., John, E.M., Smith, M. (2000) Assessing phytoestrogen exposure in epidemiologic studies: development of a database (United States). *Cancer Causes and Control*, **11**, 289–298.
21. Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. & Prior, R.L. (2004) Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *Journal of Agricultural and Food Chemistry*, **52**, 4026–4037.

22. Liggins, J., Bluck, L.J.C., Runswick, S., Atkinson, C., Coward, W.A. & Bingham, S.A. (2000) Daidzein and genistein content of fruits and nuts. *Journal of Nutritional Biochemistry*, **11**, 326–331.
23. Franke, A.A., Custer, L.J., Arakaki, C. & Murphy, S.P. (2004) Vitamin C and flavonoid levels of fruits and vegetables consumed in Hawaii. *Journal of Food Composition and Analysis*, **17**, 1–35.
24. Harnly, J.M., Doherty, R.F., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Bhagwat, S., Gebhardt, S. (2006) Flavonoid content of U.S. fruits, vegetables, and nuts. *Journal of Agricultural and Food Chemistry*, **54**, 9966–9977.
25. Thompson, L.U., Boucher, B.A., Liu, Z., Cotterchio, M. & Kreiger, N. (2006) Phytoesterogen content of foods consumed in Canada, including isoflavones, lignans, and coumestan. *Nutrition and Cancer*, **54**, 184–201.
26. Donovan, J.L., Meyer, A.S. & Waterhouse, A.L. (1998) Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica*). *Journal of Agricultural and Food Chemistry*, **46**, 1247–1252.
27. Slatnar, A., Klancar, U., Stampar, F. & Veberic, R. (2011) Effect of drying of figs (*Ficus carica* L.) on the contents of sugars, organic acids, and phenolic compounds. *Journal of Agricultural and Food Chemistry*, **59**, 11696–11702.
28. Vayalil, P.K. (2012) Date fruits (*Phoenix dactylifera* Linn): an emerging medicinal food. *Critical Reviews in Food Science and Nutrition*, **52**, 249–271.
29. USDA (2004) *USDA Database for the Proanthocyanidin Content of Selected Foods*. Published online at: http://www.ars.usda.gov/nutrientdata, last accessed March 9, 2011.
30. Gu, L., Kelm, M.A., Hammerstone, J.F., Beecher, G., Holden, J., Haytowitz, D. & Prior, R.L. (2003) Screening of foods containing proanthocyanidins and their structural characterization using LC-MS/MS and thiolytic degradation. *Journal of Agricultural and Food Chemistry*, **51**, 7513–7521.
31. Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. & Prior, R.L. (2004) Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *Journal of Agricultural and Food Chemistry*, **52**, 4026–4037.
32. Vinson, J.A., Zubik, L., Bose, P., Samman, N. & Proch, J. (2005) Dried fruits: Excellent *in vitro* and *in vivo* antioxidants. *Journal of the American College of Nutrition*, **24**, 44–50.
33. Vinson, J.A., Su, X., Zubik, L. & Bose, P. (2001) Phenol antioxidant quality and quantity in foods: fruits. *Journal of Agricultural and Food Chemistry*, **49**, 5315–5321.
34. Kaliora, A.C., Kountouri, A.M. & Karathanos, V.T. (2009) Antioxidant properties of raisins (*Vitis vinifera* L.). *Journal of Medicinal Food*, **12**, 1302–1309.
35. Kayano, S.-I., Kikuzaki, H., Fukutsuka, N., Mitani, T. & Nakatani, N. (2002) Antioxidant activity of prune (*Prunus domestica* L.) constituents and a new synergist. *Journal of Agricultural and Food Chemistry*, **50**, 3708–3712.
36. Chun, O.K., Kim, D.-O., Smith, N., Schroeder, D., Han, J.T. & Lee, C.Y. (2005) Daily consumption of phenolics and total antioxidant capacity from fruits and vegetables in the American diet. *Journal of the Science of Food and Agriculture*, **85**, 1715–1724.
37. Madrau, M.A., Sanguinetti, A.M., Del Caro, A., Fadda, C. & Piga, A. (2010) Contribution of melanoidins to the antioxidant activity of prunes. *Journal of Food Quality*, **33**, 155–170.
38. Pellegrini, N., Serafini, M., Salvatore, S., Del Rio, D., Bianchi, M. & Brighenti, F. (2006) Total antioxidant capacity of spices, dried fruits, nuts, pulses, cereals and sweets consumed in Italy assessed by three different *in vitro* assays. *Molecular Nutrition & Food Research*, **50**, 1030–1038.
39. Ishiwata, K., Yamaguchi, T., Takamura, H. & Matoba, T. (2004) DPPH radical-scavenging activity and polyphenol content of dried fruits. *Food Science and Technology Research*, **10**, 152–156.
40. Vinson, J.A., Zubik, L., Bose, P., Samman, N. & Proch, J. (2005) Dried fruits: Excellent *in vitro* and *in vivo* antioxidants. *Journal of the American College of Nutrition*, **24**, 44–50.
41. Vinson, J.A., Su, X., Zubik, L. & Boase, P. (2001) Phenol antioxidant quantity and quality in foods: Fruits. *Journal of Agricultural and Food Chemistry*, **49**, 5315–5321.
42. Shahidi, F. & Ho, C.-T. (2005) Phenolics in food and natural health products: an overview. In: *Phenolic Compounds in Foods and Natural Products* (eds F. Shahidi & C.-T. Ho). ACS Symposium Series 909, American Chemical Society, Washington, DC, pp. 1–8.
43. Kuhnau, J. (1976) The flavonoids: a class of semi-essential food components: their role in human nutrition. *World Review of Nutrition and Dietetics*, **24**, 117–191.
44. Chiou, A., Karathanos, V.T., Mylona, A., Salta, F.N., Preventi, F. & Andrikopoulos, N.K. (2007) Currants (*Vitis vinifera* L.) content of simple phenolics and antioxidant activity. *Food Chemistry*, **102**, 516–522.

45. Nakatani, N., Kayano, S.-I., Kikuzaki, H., Sumino, K., Katagiri, K. & Mitani, T. (2000) Identification, quantitative determination, and antioxidative activities of chlorogenic acid isomers in prune (*Prunus domestica* L.). *Journal of Agricultural and Food Chemistry*, **48**, 5512–5516.
46. Fang, N., Shanggong, Y. & Prior, R.L. (2002) LC/MS/MS characterization of phenolic constituents in dried plums. *Journal of Agricultural and Food Chemistry*, **50**, 3579–3585.
47. Al-Farsi, M., Alasalvar, C., Morris, A., Barron, M. & Shahidi, F. (2005) Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. *Journal of Agricultural and Food Chemistry*, **53**, 7592–7599.
48. Al-Farsi, M. & Lee, C.Y. (2008) Nutritional and functional properties of dates: a review. *Critical Reviews in Food Science and Nutrition*, **48**, 877–887.
49. Tinker, L.F., Davis, P.A., Schneeman, B.O., Gallaher, D.D. & Waggoner, C.R. (1991) Consumption of prunes as a source of dietary fiber in men with mild hypercholesterolemia. *American Journal of Clinical Nutrition*, **53**, 1259–1265.
50. Camire, M.E. & Dougherty, M.P. (2003) Raisin dietary fiber composition and *in vitro* bile acid binding. *Journal of Agricultural and Food Chemistry*, **51**, 834–837.
51. Carughi, A. (2009) Raisins as a source of prebiotic compounds in the diet. *FASEB Journal*, **23**, 716.9.
52. Spiller, G.A., Story, J.A., Furumoto, E.J., Chezem, J.C. & Spiller, M. (2003) Effect of tartaric acids and dietary fiber from sun-dried raisins on colonic function and on bile acid and volatile fatty acid excretion in healthy adults. *British Journal of Nutrition*, **90**, 803–807.
53. Block, G., Patterson, B. & Subar, A. (1992) Fruit, vegetables, and cancer prevention: a review of the epidemiological evidence. *Nutrition and Cancer*, **18**, 1–29.
54. Steinmetz, K.A. & Potter, J.D. (1996) Vegetables, fruits and cancer prevention: a review. *Journal of the American Dietetic Association*, **10**, 1027–1039.
55. Tantamango, Y.M., Knutsen, S.F., Beeson, W.L., Fraser, G. & Sabate, J. (2011) Food and food groups associated with the incidence of colorectal polyps: the Adventist health study. *Nutrition and Cancer*, **63**, 565–572.
56. Rimm, E.B., Ascherio, A., Giovanucci, E., Speigelman, D., Stampfer, M.J. & Willett, W.C. (1996) Vegetable, fruit and cereal fiber intake and risk of coronary heart disease among men. *Journal of the American Medical Association*, **275**, 447–451.
57. Hu, B. (2003) Plant-based foods and prevention of cardiovascular disease: an overview. *American Journal of Clinical Nutrition*, **78** (Suppl.), 544S–551S.
58. Joshipura, K.J., Ascherio, A., Manson, J.E., Stampfer, M.J., Rimm, E.B., Speizer, F.E., Hennekens, C.H., Spiegelman, D., Willett, W.C. (1999) Fruit and vegetable intake in relation to risk of ischemic stroke. *Journal of the American Medical Association*, **282**, 1233–1239.
59. Schröder, H. (2007) Protective mechanisms of the Mediterranean diet in obesity and type 2 diabetes. *Journal of Nutritional Biochemistry*, **18**, 149–160.
60. Ford, E.S. & Mokdad, A.H. (2001) Fruit and vegetable consumption and diabetes mellitus incidence among U.S. adults. *Preventive Medicine*, **32**, 33–39.
61. Ascherio, A., Stamper, M.J., Colditz, G.A., Willett, W.C. & McKinlay, J. (1991) Nutrient intakes and blood pressure in normotensive males. *International Journal of Epidemiology*, **20**, 886–891.
62. WHO/FAO (2003) *Diet, Nutrition and the Prevention of Chronic Disease. Report of a Joint FAO/WHO Expert Consultation*. WHO, Geneva, Switzerland.
63. Halloran, B.P., Wronski, T.J., VonHerzen, D.C., Chu, V., Xia, X., Pingel, J.E., Williams, A.A. & Smith, B. (2010) Dietary dried plum increases bone mass in adult and aged male mice. *Journal of Nutrition*, **140**, 1781–1787.
64. Hooshmand, S. & Arjmandi, B.H. (2009) Viewpoint: dried plum, an emerging functional food that may effectively improve bone health. *Aging Research Reviews*, **8**, 122–127.
65. Hertog, M.G.L., Feskens, E.J.M., Hollman, P.C.H., Katan, M.B. & Kromhout, D. (1993) Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study. *Lancet*, **342**, 1007–1011.
66. Keli, S.O., Hertog, M.G., Feskens, E.J. & Kromhout, D. (1996) Dietary flavonoids, antioxidant vitamins, and incidence of stroke: the Zutphen study. *Archives of Internal Medicine*, **156**, 637–642.
67. Neuhouser, M.L. (2004) Flavonoids and cancer prevention: what is the evidence in humans? *Pharmaceutical Biology*, **42**, 36–45.
68. Wang, H., Cao, G., & Prior, R.L. (1996) Total antioxidant capacity of fruits. *Journal of Agricultural and Food Chemistry*, **44**, 701–705.
69. Pietta, P.-G. (2000) Flavonoids as antioxidants. *Journal of Natural Products*, **63**, 1035–1042.

70. Spiller, G.A., Story, J.A., Lodics, T.A., Pollack, M., Monyan, S., Butterfield, G., Spiller, M. (2003) Effect of sun-dried raisins on bile acid excretion, intestinal transit time, and fecal weight: a dose response study. *Journal of Medicinal Food*, **6**, 87–91.
71. Attaluri, A., Donahoe, R., Valestin, J., Brown, K. & Rao, S.S.C. (2011) Randomised clinical trial: dried plums (prunes) vs. psyllium for constipation. *Alimentary Pharmacology & Therapeutics*, **33**, 822–828.
72. Nielsen, F.H. (2008) Is boron nutritionally relevant? *Nutrition Reviews*, **66**, 183–191. http://www.cnpp.usda.gov/dietaryguidelines.htm
73. Kashket, S., Van Houte, J., Lopez, L.R. & Stocks, S. (1991) Lack of correlation between food retention on the human dentition and consumer perception of food stickiness. *Journal of Dental Research*, **70**, 1314–1319.
74. Rivero-Cruz, J.F., Zhu, M., Kinghorn, A.D. & Wu, C.D (2008) Antimicrobial constituents of Thomson seedless raisins (*Vitis vinifera*) against selected oral pathogens. *Phytochemistry Letters*, **1**, 151–154.
75. Utreja, A., Lingström, P., Evans, C.A., Salzmann, L.B. & Wu, C.D. (2009) The effect of raisins-containing cereals on the PH of dental plaque in young children. *Pediatric Dentistry*, **31**, 498–503.
76. Appel, L.J. (2003) Lifestyle modifications as a means to prevent and treat high blood pressure. *Journal of the American Society of Nephrology*, **14**, S99–S102.
77. Keast, D.R. & Jones, J.M. (2009) Dried fruit consumption associated with reduced improved overweight or obesity in adults: NHANES, 1999–2004. *FASEB Journal*, **23**, LB511.
78. Puglisi, M.J., Mutungi, G., Brun, P.J., McGrane, M.M., Labonte, C., Volek, J.S. & Fernandez, M.L. (2009) Raisins and walking alter appetite hormones and plasma lipids by modifications in lipoprotein metabolism and up-regulation of the low-density lipoprotein receptor. *Metabolism—Clinical and Experimental*, **58**, 120–128.
79. Glycemic Index Database (2011) *Glycemic Index Databses: Sydney University's Glycemic Index Research Service (SUGIRS)*. Published online at: http://www.glycemicindex.com/, last accessed May 28, 2011.
80. Miller, C.J., Dunn, E.V. & Hashim, I.B. (2002) Glycemic Index of 3 varieties of dates. *Saudi Medical Journal*, **23**, 536–538.
81. Kim, Y., Hertzler, S.R., Byrne, H.K. & Mattern, C.O. (2008) Raisins are a low to moderate glycemic index food with a correspondingly low insulin index. *Nutrition Research*, **28**, 304–308.
82. Anderson, J.A., Huth, H.A., Larson, M.M., Colby, A.J., Krieg, E.J., Golbach, L.P., Simon, K.A., Wasmundt, S.L., Malone, C.J. & Wilson, T. (2011) Glycemic and insulin response to raisins, grapes and bananas in college aged students. *FASEB Journal*, **25**, 587.4
83. Anderson, J.A., Andersen, K.F., Heimerman, R.A., Larson, M.M., Baker, S.E., Freeman, M.R., Carughi, A. & Wilson, T. (2011) Glycemic response of type 2 diabetics to raisins. *FASEB Journal*, **25**, 587.5
84. Zunino, S.J. (2009) Type 2 diabetes and glycemic response to grapes or grape products. *Journal of Nutrition*, **139** (Suppl.), 1794S–8000S.
85. Johnston, K.L., Clifford, M.N. & Morgan, L.M. (2003) Coffee acutely modifies gastrointestinal hormone secretion and glucose tolerance in humans: glycemic effects of chlorogenic acid and caffeine. *American Journal of Clinical Nutrition*, **78**, 728–733.
86. Björck, I. & Elmståhl, H.L. (2003) The glycemic index: importance of dietary fibre and other food properties. *Proceedings of the Nutrition Society*, **62**, 201–206.
87. Widanagamage, R.D., Ekanayake, S. & Welihinda, J. (2009) Carbohydrate-rich foods: glycemic indices and the effect of constituent macronutrients. *International Journal of Food Science and Nutrition*, **60**, 215–223.
88. Keast, D.R., O'Neil, C.E. & Jones, J.M. (2011) Dried fruit consumption is associated with improved diet quality and reduced obesity in US adults: National Health and Nutrition Examination Survey, 1999–2004. *Nutrition Research*, **31**, 460–467.
89. Meduri Farm Inc. (2011) *Specialty Dried Fruits*. Published online at: http://www.medurifarms.com, last accessed July 18, 2011.
90. USDA (2010) *Dietary Guidelines for Americans*. Published online at: http://www.cnpp.usda.gov/dietaryguidelines.htm, last accessed June 1, 2011.
91. FAO (2011) *Food Based Dietary Guidelines*. Published online at: http://www.fao.org/ag/humannutrition/nutritioneducation/fbdg/en, last accessed June 1, 2011.